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Obesity Aggravates the Clinical Profile of COVID-19 Patients Hospitalized in the North of Mato Grosso, Brazil: A Cohort Study

Karla Kelly Paniago Miranda dos Santos [1], Mauro André Azevedo Silva Kaiser Cabral [2], Vinícius Tadeu Ribeiro Mattar [2], Felipe Cézar de Oliveira Costa [2], Rayane Manoel Garcia [2], Breno Marcos Brito do Valle [2], Diogo Albino de Queiroz [3,4], André Ferreira do Nascimento [1], Renata de Azevedo Melo Luvizotto [1] and Eveline Aparecida Isquierdo Fonseca de Queiroz [1,*]

[1] Programa de Pós-Graduação em Ciências em Saúde, Instituto de Ciências da Saúde, Campus Universitário de Sinop, Universidade Federal do Mato Grosso, Sinop 78550-728, MT, Brazil; kkarla_pms@hotmail.com (K.K.P.M.d.S.); nascimentoaf@yahoo.com.br (A.F.d.N.); renata.nascimento@ufmt.br (R.d.A.M.L.)
[2] Instituto de Ciências da Saúde, Campus Universitário de Sinop, Universidade Federal do Mato Grosso, Sinop 78550-728, MT, Brazil; mauro.cabral@sou.ufmt.br (M.A.A.S.K.C.); viniciusmattar00@gmail.com (V.T.R.M.); felipe.costa1@sou.ufmt.br (F.C.d.O.C.); rayanegarcia040@gmail.com (R.M.G.); breno_valle@outlook.com (B.M.B.d.V.)
[3] Gestão de Administração e Planejamento, Campus Universitário de Sinop, Universidade Federal do Mato Grosso, Sinop 78550-728, MT, Brazil; diogo.queiroz@ufmt.br
[4] Escola Técnica Estadual de Educação Profissional e Tecnológica, Unidade de Sinop, Sinop 78557-673, MT, Brazil
* Correspondence: eveline.queiroz@ufmt.br; Tel.: +55-66-98130-6664

Abstract: COVID-19, caused by the SARS-CoV-2 coronavirus, has significantly impacted global health, particularly among patients with obesity. This study evaluates the prevalence and effects of overweight and obesity on the clinical profiles and complications of COVID-19 patients admitted to a hospital in Northern Mato Grosso. We conducted a retrospective cohort study analyzing medical records of COVID-19 patients hospitalized from March 2020 to March 2021. Patients were classified into normal body weight, overweight, and obesity groups. Data were statistically analyzed using Kruskal–Wallis's test and Dunn's post-test (continuous variables) or by the chi-square test (χ^2) (categorical variables). Among 145 ward records, 24.1% were normal body weight, 46.2% were overweight, and 29.7% were obese. In the intensive care unit, data from 243 patients indicated that 17.3% were normal body weight, 37.9% were overweight, and 44.9% were obese, highlighting a concerning prevalence of overweight/obesity. Chest computed tomography revealed that moderate pulmonary involvement (25–50%) was most frequent in the overweight group, while severe involvement (>50%) was predominant in the obesity group. The obesity group experienced more complications, including increased use of mechanical ventilation. Notably, in both settings, mortality rates were higher among patients with overweight and obesity. This study concludes that overweight and obesity significantly worsen COVID-19 outcomes.

Keywords: SARS-CoV-2; overweight; complications; mechanical ventilation; death

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1. Introduction

COVID-19 is a disease caused by the SARS-CoV-2 virus, discovered at the end of 2019 in the province of Wuhan, China after reported cases of pneumonia of unknown cause that quickly had a significant impact worldwide. It was later named Severe Acute Respiratory Syndrome (SARS) [1,2].

With its rapid spread and unstable behavior, COVID-19 has become a pandemic and a notable public health emergency, with a high contagion rate and a broad spectrum of manifestations [1,3].

SARS-CoV-2 is a single RNA zoonotic virus belonging to the *Coronaviridae* family, which, when infecting a healthy cell, translates and replicates the viral RNA, culminating in the synthesis of new viruses and their structuring proteins: proteins E, M, N, and S. The S protein is responsible for the formation of spikes, which allow SARS-CoV-2 to bind to angiotensin-converting enzyme 2 (ACE2) and enter human cells. During SARS-CoV-2 infection, the S-ACE2 protein complex is internalized into the cell, resulting in the loss of function of the plasma-membrane-bound ACE2 [4,5].

It is known that ACE2, in typical situations, has anti-inflammatory action, and it is known as a protective factor for cases of acute respiratory failure syndrome. Thus, due to the internalization and loss of ACE2 function, patients affected by SARS-CoV-2 are more predisposed to present with this syndrome [6].

The renin–angiotensin–aldosterone system (RAAS) controls blood pressure, renal function, and inflammatory action. The RAAS cascade begins with angiotensinogen, produced by the liver and cleaved by the action of renin (produced by the kidneys), forming angiotensin I (Ang I). Ang I undergoes the action of the ACE being cleaved and forming angiotensin II (Ang II), which binds to its AT1 receptor (AT1R) and, to a lesser extent, to the AT2 receptor (AT2R), generating its effects. The action of Ang II on the AT1R promotes vasoconstriction, stimulates the release of aldosterone, and promotes an essential pro-inflammatory and pro-fibrotic impact, among others. In addition, the aldosterone regulates sodium (Na+) reabsorption and potassium (K+) excretion, contributing to blood pressure regulation and homeostasis [6].

ACE2 acts as a negative control, maintaining RAAS balance and homeostasis, as it converts Ang II to angiotensin 1-7 and Ang I to angiotensin 1-9, subsequently converted to Ang 1-7 by ACE or other peptides. Ang 1-7 binds to the mitochondrial assembly receptor (MassR), promoting vasodilation and anti-inflammatory and anti-fibrotic effects [7]. Thus, the decrease in ACE2 enzyme due to SARS-CoV-2 infection increases the activation of the Ang II/AT1R complex, increasing the expression of pro-inflammatory cytokines and possibly causing systemic damage in the body; it also promotes vasoconstriction and contributes to increased blood pressure [7].

It is known that ACE2 is expressed in several regions of the body, with greater expression of ACE2 in the following tissues/organs: the lungs, the intestine, and white adipose tissue. This demonstrates a greater involvement of these tissues and organs in patients affected by COVID-19 and many signs and symptoms presented by patients [6].

Non-communicable diseases and injuries have been increasing, and, in Brazil, they are the leading causes of death in adults, with obesity being one of the highest risk factors for illness [8].

Excess adiposity can also promote the development of other comorbidities, such as type 2 diabetes mellitus, gestational diabetes mellitus, cardiovascular disease, hypertension, dyslipidemia, and various types of cancer [9–11]. In addition, it causes chronic low-grade inflammation, elevating the level of some cytokines and chemokines compared to a thin individual. Consequently, innate and first-line immune cell responses are compromised, causing damage, including to the airway mucosa [12].

In addition, the heightened immune response to SARS-CoV-2 triggers a cytokine storm and a state of hyperinflammation. In obesity, the increase in inflammation in adipose tissue is already a reality, with an increase in the number of leukocytes and lymphocytes, increased oxidative and phagocytic activity, increased production of pro-inflammatory adipokines, and increased oxidative stress. Thus, the sum of the pre-existing inflammation caused by obesity and that promoted by the SARS-Cov-2 infection generates a state of hyperinflammation and serious consequences for the patient [7,13].

Different adipose tissue cells (adipocytes, endothelial cells, stromal cells, and macrophages) are targets of different viruses [14]. Furthermore, such cells also express the ACE2 protein [15], indicating that obese individuals may have a high viral load for SARS-CoV-2 and, consequently, greater dissemination of this virus, as the protein ACE2 facilitates the entry of the virus into the cells. Thus, the chronic inflammation present in obese individuals and the tropism of SARS-CoV-2 for tissues with ACE2 expression can lead to the development of a more severe picture of the disease [16].

Thus, the objective of the present study was to analyze the clinical and epidemiological profile of patients diagnosed with COVID-19 from March 2020 to March 2021 admitted to a ward and intensive care unit (ICU) in the north of Mato Grosso and the impact of overweight and obesity on the clinical profile and the prognosis of these patients.

This study is important to demonstrate the clinical and epidemiological profile of patients from the north of Mato Grosso state in accordance with their BMI. Furthermore, this article reinforces the importance of obesity and the negative impact of obesity on patients hospitalized with COVID-19. This research is of utmost importance to demonstrate the scenario of hospitalized patients with COVID-19 in Brazil (before the vaccination period), mainly in the northern region of the Mato Grosso, and it is relevant to demonstrate the negative influence that obesity can produce in patients with viral infection, contributing to the scientific and health community, such as researchers, doctors, nurses, psychologists, physiotherapists, and pharmacists, among others

2. Materials and Methods

This article is a retrospective cohort study with a quantitative approach, with data collected from March 2020 to March 2021 at the Hospital Regional Jorge de Abreu (HRJA) in Sinop, Mato Grosso (MT), a municipality located in the north of the state of MT, Brazil. The data collected were from patients assisted by the health insurance classified as SUS (Unified Health System). Data collection occurred during weekly visits to the HRJA and through reading, analysis, and electronic recording of medical records in Excel spreadsheets.

Clinical and epidemiological data were collected from the medical records of patients diagnosed with COVID-19 (rapid test with Nasopharyngeal Swab sample, presence and/or RT-PCR laboratory test) and admitted to the HRJA in the ward and in the ICU who had body mass index (BMI) data in their medical records. The identity of the research subjects was kept confidential.

Data collection was carried out through the analysis of medical records made available by the health team, where the following data were collected and analyzed: general data (gender, age, city of origin, and smoking), anthropometric measurements (weight, height, BMI), clinical history (presence of comorbidities, such as asthma, chronic obstructive pulmonary disease (COPD), type 2 diabetes mellitus (type 2 DM), and systemic arterial hypertension, and incident illnesses, such as pneumonia), and evolution of the patient's hospitalization (days of symptoms, types of symptoms, necessity of mechanical ventilation, tracheostomy, incidence of other complications, therapeutic profile, and death). Medical records of patients younger than 18 years old were excluded from the analysis.

Inclusion criteria: medical records of patients diagnosed with COVID-19 in 2020 and 2021 (March 2020 to March 2021, with exam positive for COVID-19), with or without comorbidities, with BMI data present in their medical records, obese or not, and hospitalized in the HRJA during this period.

Exclusion criteria: medical records of patients younger than 18 years old and all underweight patients (BMI $\leq$ 18.5 kg/m^2).

To better analyze the clinical and epidemiological profile of obese and non-obese hospitalized patients with COVID-19, the data of patients were divided into three groups: (1) normal body weight group: patients with COVID-19 and BMI $\geq$ 18.6 kg/m^2 and $\leq$24.9 kg/m^2; (2) overweight group: patients with COVID-19 and BMI $\geq$ 25.0 kg/m^2 and $\leq$29.9 kg/m^2; and (3) obesity group: patients with COVID-19 and BMI $\geq$ 30.0 kg/m^2.

The risks arising from handling the medical records could be loss and possible damage, so, to avoid them, the measures adopted were manipulating the medical records only in the place where they were, that is, in the HRJA, and no material that could damage them was manipulated during the reading of the medical records.

As a benefit, the participants indirectly contributed to the research with information present in their medical records, which helped to better understand the clinical and epidemiological profile of patients with COVID-19 admitted to an HRJA in Sinop, MT.

Data were tabulated in a Microsoft® Excel® Software Spreadsheet (Office 365) and used to perform the descriptive analysis by evaluating the distribution of frequencies (absolute and percentage data).

The statistical analyses were performed using the GraphPad Prism® 8 program. Initially, if the data passed the Kolmogorov–Smirnov normality test and Bartlett's homogeneity test, the results were statistically evaluated using the One-Way ANOVA test and Tukey's post-test for the quantitative analysis of continuous variables. In cases where the results did not pass the normality test or the homogeneity test, Kruskal–Wallis's test and Dunn's post-test were performed. In the case of categorical variables analysis, the chi-square test (χ^2) was used. Furthermore, the odds ratio (OR) and the 95% confidence interval (CI) comparing two groups, the obesity group vs. the normal body weight group, were calculated, and the multivariate regression analysis (multiple linear regression) was performed to determine the association between deaths and BMI. In the model, death (the variable outcome) was the dependent variable, while BMI (the explanatory variable) was the independent variable. This test was performed at the 95% confidence level.

Data are presented as the mean $\pm$ standard deviation (SD), as the median and the interquartile and in percentage (%), or as the 95% confidence interval (CI). The minimum acceptable level of significance was $p < 0.05$.

3. Results

3.1. Epidemiological Profile of Patients with COVID-19 Admitted to the Ward

Data were collected from 410 medical records of patients admitted to the ward. Eleven patients were excluded from the survey because they did not have a confirmatory diagnosis of COVID-19 using the rapid test with Nasopharyngeal Swab sample presence and/or the RT-PCR laboratory test during their hospitalization, thus totaling a sample of 399 medical records. Of these, 254 records were eliminated, 2 of which included low body weight patients and 252 because they did not have the weight or height to define their BMI; thus, the analysis of the influence of obesity on the clinical course of COVID-19 included 145 patients with BMI data.

Among the 145 patients admitted to the ward, 35 were normal body weight, 67 were overweight, and 43 were patients with obesity. Most patients were over 50 years old, married, non-smokers, and white (Table 1). It was observed that the median age of patients was significantly lower in the obesity group (50 years old) compared to the normal body weight group (61 years old), $p = 0.03$, suggesting that obesity may be contributing to younger patients presenting with more severe clinical symptoms and being hospitalized. The gender variable showed a statistical difference between the groups, $p = 0.02$, with males more frequently in the normal body weight and overweight groups and females more frequently in the obesity group. Furthermore, no statistical differences between groups were observed regarding marital status, ethnicity, or smoking habits. Although most of the patients in this study were identified as non-smokers, it is necessary to consider the number of medical records that did not present this information (n = 23).

Table 1. Distribution and analysis of COVID-19 hospitalized patients in the ward at the Hospital Regional Jorge de Abreu in Sinop, MT and in accordance with epidemiological and clinical variables and BMI from March 2020 to March 2021.

Variables	Normal Body Weight	Overweight	Obesity	Total	*p*
n (%)	35 (24.1)	67 (46.2)	43 (29.7)	145 (100.0)	---
Body weight (kg) &	66 (62–69)	80 (73–85) *	90(85–109) *	80 (69–90)	<0.0001
BMI (kg/m^2) &	24 (23–25)	27 (26–28) *	34 (31–39) *	27 (25–30)	<0.0001
Age &	61 (49–67)	56 (45–66)	50 (39–60) *	56 (43–65)	0.03
Sex	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.02
Male	26 (74.2)	48 (71.6)	21 (48.8)	96 (65.7)	
Female	9 (25.7)	19 (28.3)	22 (51.1)	50 (34.2)	
Marital status	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.72
Married	11 (31.4)	40 (58.8)	17 (40.4)	68 (46.9)	
Single	5 (14.3)	6 (8.8)	4 (9.5)	15 (10.3)	
Common-law marriage	3 (8.5)	5 (7.3)	2 (4.7)	10 (6.9)	
Widowed or divorced	2 (5.7)	6 (8.8)	4 (9.5)	12 (8.2)	
Not informed	14 (40.0)	11 (16.1)	15 (35.7)	40 (27.6)	
Ethnicity	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.21
White	14 (35.8)	35 (52.2)	18 (41.8)	67 (46.2)	
Brown	12 (30.7)	20 (29.8)	8 (18.6)	40 (27.6)	
Yellow	3 (17.9)	5 (7.4)	10 (23.2)	18 (12.4)	
Black and Indigenous	4 (10.2)	6 (8.9)	6 (13.9)	16 (11.0)	
Not informed	2 (5.1)	1 (1.5)	1 (2.3)	4 (2.7)	
Smoking	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.18
Yes	6 (17.1)	16 (23.8)	4 (9.3)	26 (17.9)	
No	23 (64.7)	42 (62.7)	31 (72.1)	96 (66.2)	
Not informed	6 (17.1)	9 (13.4)	8 (18.6)	23 (15.8)	
Diabetes mellitus	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.01
Yes	5 (14.2)	18 (26.7)	19 (44.2)	42 (3.7)	
No	30 (85.7)	47 (69.1)	24 (55.8)	101 (93.6)	
Not informed	0 (0.0)	3 (4.4)	0 (0.0)	3 (2.7)	
Presence of respiratory diseases	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.15
Yes	6 (17.1)	9 (14.3)	2 (4.7)	17 (11.7)	
No	25 (71.4)	52 (82.5)	39 (92.8)	116 (80.0)	
Not informed	4 (11.4)	6 (3.2)	2 (2.3)	12 (8.3)	
Cardiovascular diseases	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.72
Yes	18 (51.4)	40 (59.7)	24 (54.5)	82 (56.5)	
No	17 (48.6)	27 (40.3)	19 (43.2)	63 (43.4)	
Not informed	0 (0.0)	0 (0.0)	1 (2.2)	0 (0.0)	

Table 1. *Cont.*

Variables	Normal Body Weight	Overweight	Obesity	Total	*p*
What pre-existing cardiovascular diseases?	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.49
Hypertension	6 (33.3)	15 (37.5)	9 (37.5)	30 (36.6)	
Hypertension + heart failure	5 (27.7)	18 (45.0)	9 (37.5)	32 (39.0)	
Other heart diseases	7 (38.8)	7 (17.5)	6 (25.0)	20 (24.4)	
Other chronic comorbidities	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.001
Yes	16 (45.7)	10 (14.9)	8 (18.9)	34 (23.4)	
No	16 (45.7)	51 (76.1)	31 (72.1)	98 (64.6)	
Not informed	3 (8.5)	6 (8.9)	4 (9.3)	13 (8.9)	
What other pre-existing chronic comorbidities?	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.91
Chronic dialysis kidney disease	5 (31.2)	4 (40.0)	2 (25.0)	11 (32.3)	
Neoplasms	3 (18.7)	2 (20.0)	1 (12.5)	6 (17.6)	
Others (depression, anxiety)	8 (50.0)	4 (40.0)	5 (62.5)	17 (50.0)	

Results are expressed as the median and the interquartile (IQ) or as the number of individuals and the percentage (*n* (%)). Statistical analysis: [&] *Kruskal–Wallis* test with Dunn's post-test for quantitative variables and chi-square test (χ^2) for categorical variables. The variables for which there was no information in the medical record were not included in the statistical tests. * $p < 0.05$ vs. normal body weight group. There was only one Indigenous person in the normal body weight group.

3.2. Clinical Profile of Patients with COVID-19 Admitted to an HRJA Ward

Our study shows that most patients admitted to the ward had a BMI ≥ 25 kg/m^2 (overweight), as shown in Table 1, highlighting how the presence of overweight is a significant risk factor for a worse prognosis for COVID-19 necessitating hospitalization, in line with several studies that have evaluated this relationship.

In the present study, of the total sample of 145 patients with BMI data, a statistically significant higher prevalence of diabetes mellitus was observed in the overweight and obesity group when compared to the normal body weight group. In the normal body weight group, five (14.3%) had the disease, in the overweight group, 18 had the disease (26.7%), and in the obesity group, 19 had the disease (44.2%), with $p = 0.01$ (Table 1).

In addition, six (17.1%) of the normal body weight patients had respiratory diseases, nine (14.3%) of the overweight patients, and two (4.7%) patients from the obesity group. No statistical significance was found for respiratory diseases between these groups, $p = 0.15$. These diseases include COPD ($n = 11$), asthma ($n = 3$), pulmonary emphysema ($n = 1$), bronchiectasis ($n = 1$), and COPD + pneumoperitoneum ($n = 1$).

In the context of patients with cardiovascular diseases, there was no statistically significant difference in the comparison between groups. Among the normal body weight patients, 18 (51.4%) had cardiovascular pathologies, as well as 40 (59.7%) of the patients in the overweight group and 24 (55.8%) of the patients in the obesity group, $p = 0.72$. Among cardiovascular diseases, they included systemic arterial hypertension, congestive heart failure, and other heart diseases.

Regarding other chronic comorbidities of the patients who had other chronic diseases, 16 (45.7%) were normal body weight, 10 (14.9%) were overweight, and 8 (18.9%) were obese. The chronic comorbidities verified in this study are chronic kidney disease, renal disease, chronic dialysis, neoplasms, and others, such as depression and anxiety, whose distributions are described in Table 1. In addition, according to other incident disease, such as dengue, no difference was observed between groups, and 31.7% of patients presented these comorbidities. Among the incident diseases, the ward patients presented dengue fever (n = 18), history of previous surgery (n = 16), urinary infection (n = 13), pneumonia (n = 12), anemia (n = 7), leprosy (n = 8), women in postpartum (n = 4), prostatic hyperplasia (n = 12), and hearing impairment (n = 4).

In Table 2, it is evident that most patients admitted to the ward presented ≥ 8 days of symptoms (p = 0.50). No difference was observed between groups; however, it is important to note that in the normal body weight group, the patients presented 1–7 days of symptoms, but in patients with overweight/obesity, they presented more than 8 days of symptoms. The predominant symptoms observed in these patients were dyspnea, followed by cough and fever, which were similar between the groups (p = 0.12).

Table 2. Distribution and analysis of clinical profile of COVID-19 hospitalized patients in the ward at the Hospital Regional Jorge de Abreu in Sinop, MT and in accordance with BMI from March 2020 to March 2021.

Variables	Normal Body Weight	Overweight	Obesity	Total	*p*
n (%)	35 (24.1)	67 (46.2)	43 (29.7)	145 (100)	-
Total hospitalization days [&]	7 (6–9)	8 (6–9)	9 (7–11)	8 (6–9)	0.21
Days of symptoms	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.50
1 to 7	18 (51.4)	29 (43.3)	17 (39.5)	64 (44.2)	
≥8 days	16 (45.7)	36 (53.7)	26 (60.5)	72 (49.7)	
Not informed	1 (2.9)	2 (3.0)	0 (0.0)	2 (1.4)	
Main symptoms	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.12
Dyspnea	18 (34.6)	21 (26.6)	20 (23.2)	59 (27.2)	
Cough	10 (19.2)	20 (25.3)	17 (19.7)	47 (21.6)	
Fever	9 (17.3)	18 (22.8)	15 (17.4)	42 (19.3)	
Myalgia	3 (5.7)	4 (5.0)	13 (15.1)	20 (9.2)	
Anosmia/hypogeusia	1 (1.9)	3 (3.8)	7 (8.1)	11 (5.0)	
Headache	2 (3.8)	5 (6.3)	9 (10.5)	16 (7.4)	
Others	9 (17.3)	8 (10.1)	5 (5.8)	22 (10.2)	
Chest CT scan	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.42
Yes	29 (82.8)	53 (79.1)	39 (90.7)	117 (82.4)	
No	5 (14.3)	10 (14.9)	4 (9.3)	19 (13.4)	
Not informed	1 (2.8)	4 (5.9)	0 (0.0)	6 (4.2)	
Image pattern found	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.01
Mild impairment (<25%)	9 (31.0)	17 (33.3)	6 (14.3)	32 (26.5)	
Moderate commitment (25–50%)	13 (44.8)	25 (49.1)	14 (33.3)	52 (43.0)	
Marked or severe (>50%)	5 (17.02)	7 (13.7)	20 (47.6)	32 (26.5)	
Other reports	2 (6.9)	2 (3.9)	2 (4.7)	6 (5.0)	
Mechanical ventilation	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.04
Yes	8 (23.5)	21 (31.3)	21 (48.8)	50 (34.5)	
No	26 (76.5)	46 (68.6)	22 (51.2)	94 (65)	
Tracheostomy	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.42
Yes	3 (8.3)	3 (4.5)	5 (11.6)	11 (7.5)	

Table 2. *Cont.*

Variables	Normal Body Weight	Overweight	Obesity	Total	*p*
No	32 (88.9)	64 (95.5)	37 (86)	133 (91)	
Not informed	1 (2.7)	0 (0.0)	1 (2.3)	2 (1.4)	
Other complications	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.01
Yes	2 (5.7)	12 (17.9)	16 (37.2)	30 (20.7)	
No	33 (94.3)	54 (80.6)	27 (62.8)	114 (78.6)	
Not informed	0 (0.0)	1 (1.5)	0 (0.0)	1 (0.7)	
Death	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.002
Yes	3 (8.8)	12 (18.4)	14 (29.2)	29 (19.7)	
No	31 (91.2)	52 (80.0)	28 (58.3)	111 (75.5)	
Transferred to another hospital	0 (0.0)	1 (1.5)	6 (12.5)	7 (4.7)	

Results are expressed as the median and the interquartile (IQ) or as the number of individuals and the percentage (*n* (%)). Statistical analysis: & *Kruskal–Wallis* test with Dunn's post-test for quantitative variables and chi-square test (χ^2) for categorical variables. The variables for which there was no information in the medical record were not included in the statistical tests; they are represented as not informed. Other complications presented by the patients were hemodialysis, acute renal failure, pulmonary thromboembolism, acute myocardial infarction, and pneumonia, among others.

In our study, most patients had contact with someone positive for COVID-19 (60.7%), and there was no difference between groups regarding the signs and symptoms presented by them (Table 2). The main symptoms reported were dyspnea, cough, and fever. In addition, no statistically significant difference was observed between the days of symptoms presented by patients, $p = 0.50$ (Table 2).

Computed tomography (CT) was widely used as a complementary exam for diagnosis and clinical evaluation in the COVID-19 pandemic in this field of research. In our study, of the 145 patients who had BMI data, 122 underwent CT imaging. The group of patients with obesity had a higher incidence of the pattern of marked or severe ground-glass impairment (>50% of the lung parenchyma), $p = 0.01$ (Table 2).

In accordance with treatment of patients, it was observed that several drugs were used, such as antimicrobials (18.6%), azithromycin (18.9%), glucocorticoids (27.9%), Tamiflu® (0.5%), anticoagulants (29.1%), vasoactive drugs (4.4%), ivermectin (0.5%), and chloroquine (0.2%).

Concerning hospital complications, such as the need for mechanical ventilation, tracheostomy, and other complications, it can be observed that the incidence of these harmful outcomes was significantly higher in the obesity group when compared to the overweight and normal body weight group, demonstrating that patients with obesity have a more severe clinical condition and a higher risk of death (Tables 2 and 3). Thus, regarding the need for mechanical ventilation, among the 145 patients with BMI data, 50 required mechanical ventilation, with 21 patients being overweight and 21 being obese, with $p = 0.04$ (Table 2).

Table 3. Analysis of clinical profile, odds ratio (OR), and multiple linear regression analysis of COVID-19 hospitalized patients in the ward at the Hospital Regional Jorge de Abreu in Sinop, MT and in accordance with BMI from March 2020 to March 2021.

WARD	Normal Body Weight	Obesity	Total	OR	*p*
Mechanical ventilation	*n* (%)	*n* (%)	*n* (%)		
Yes	8 (23.5)	21 (48.8)	29 (37.7)	3.102	0.02

Table 3. *Cont.*

WARD	Normal Body Weight	Obesity	Total	OR	*p*
No	26 (76.5)	22 (51.2)	48 (62.3)	(1.197–8.678)	
Tracheostomy	*n* (%)	*n* (%)	*n* (%)		
Yes No	3 (8.6) 32 (91.4)	5 (11.9) 37 (88.1)	8 (10.4) 69 (89.6)	1.441 (0.335–5.755)	0.63
Other complications	*n* (%)	*n* (%)	*n* (%)		
Yes No	2 (5.7) 33 (94.3)	16 (37.2) 27 (62.8)	18 (23.1) 60 (76.9)	9.778 (2.204–44.81)	0.001
Death	*n* (%)	*n* (%)	*n* (%)		
Yes No	3 (8.8) 31 (91.2)	14 (33.3) 28 (66.7)	17 (22.4) 59 (77.6)	5.17 (1.41–17.97)	0.01
Multiple linear regression analysis of incidence of deaths in patients on the ward (R squared = 0.16)					
Sig. diff. than zero?	Variable	|t|	95% Confidence Interval		*p* value
β1	Age in years	2.204	0.0005302 to 0.009769		0.0292
β2	BMI	2.713	0.004078 to 0.02599		0.0075
β3	Diabetes?	2.161	0.01453 to 0.3277		0.0324
β4	CVD?	0.3025	−0.1174 to 0.1598		0.7627

Results are expressed as the number of individuals and the percentage (*n* (%)). Statistical analysis: chi-square test (χ^2) for categorical variables; OR—odds ratio with 95% confidence interval and multiple linear regression analysis. BMI = body mass index; CVD = cardiovascular disease.

Regarding the need for tracheostomy, 11 patients with BMI data required this procedure, with three patients being normal body weight, three overweight, and five obese, $p = 0.42$ (Table 2).

In our study, the most common complications on the ward were acute kidney injury, need for hemodialysis, acute lung edema, pleural effusion, pneumothorax, need for blood transfusion, stroke, deep venous thrombosis, pulmonary thromboembolism, and sepsis. When comparing the occurrence of other complications, including those already mentioned, among normal body weight, overweight, and patients with obesity, 30 patients had some of these complications, and 2 (5.7%) normal body weight patients, 12 (17.9%) were overweight, and 16 (37.2%) were obese, $p = 0.01$ (Table 2). Finally, regarding the incidence of deaths, 3 (8.8%) patients from the normal body weight group, 12 (18.7%) from the overweight group, and 14 (33.3%) from the obesity group died, with the incidence of deaths significantly higher in the obesity group, $p = 0.002$ (Table 2). Seven patients admitted to the ward did not have this information in their medical records or were transferred from the hospital.

In addition, in Table 3, the values of odds ratios can be observed for obesity vs. normal body weight groups and the incidence of complications or a worse prognosis. It was demonstrated that obesity is in fact a risk factor for the necessity of mechanical ventilation, the incidence of other complications, and death. Furthermore, in accordance with the multivariate regression analysis ($R2 = 0.1564/p < 0.0001$) described in Table 3, it can be observed that the age in years = 0.005150 (95% CI = 0.0005302–0.009769; $p = 0.0292$), obesity = 0.01503 (95% CI 0.004078 to 0.02599; $p = 0.0075$), and diabetes = 0.1711 (95% CI 0.01453 to 0.3277; $p = 0.0324$) significantly increased the risk of death in hospitalized COVID-19 patients in the ward.

3.3. Epidemiological Profile of Patients with COVID-19 Admitted to the ICU

It was observed that 24 patients admitted to the ICU were suspected of having COVID-19 and, therefore, were excluded from the study because they did not have positive exams for COVID-19.

As indicated in Table 4, most individuals belonging to all three groups were male (except for the normal body weight group), married, and self-identified as white. There was a significant difference between the groups for ethnicity, $p = 0.03$, and the frequency distribution was different in all groups, although a higher percentage of patients was self-identified as white.

Table 4. Distribution and analysis of COVID-19 hospitalized patients in the intensive care unit (ICU) at the Hospital Regional Jorge de Abreu in Sinop, MT and in accordance with epidemiological and clinical variables and BMI from March 2020 to March 2021.

Variables	Normal Body Weight	Overweight	Obesity	Total	*p*
n (%)	42 (17.3)	92 (37.9)	109 (44.9)	243 (100)	
Body weight (kg)	65 (60–75)	76 (70–80) *	100 (85–120) *	80 (75–100)	<0.0001
BMI (kg/m^2)	23 (23–25)	27 (26–29) *	35 (32–39) *	29 (26–35)	<0.0001
Age &	66 (52–75)	63 (52–71)	60 (49–69)	62 (50–70)	0.41
Sex	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.24
Male	20 (47.6)	57 (61.9)	58 (53.2)	135 (55.5)	
Female	22 (52.4)	35 (38)	51 (46.8)	108 (44.4)	
Marital status	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.73
Married	16 (38.1)	43 (46.7)	46 (42.2)	105 (43.2)	
Single	6 (14.3)	8 (8.7)	11 (10.1)	25 (10.3)	
Widowed	7 (16.7)	11 (11.9)	13 (11.9)	31 (12.7)	
Common-law marriage	2 (4.7)	6 (6.5)	14 (12.8)	22 (9.1)	
Divorced	3 (7.1)	6 (6.5)	8 (7.3)	17 (7.0)	
Not informed	8 (19)	18 (19.5)	17 (15.6)	43 (17.7)	
Ethnicity	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.03
White	16 (38.1)	35 (53.0)	18 (42.8)	118 (48.5)	
Brown	11 (26.2)	20 (30.3)	8 (19)	81 (33.3)	
Yellow	5 (11.9)	5 (7.6)	10 (23.8)	22 (9.1)	
Black	7 (16.6)	6 (9.1)	6 (14.3)	17 (7)	
Indigenous	3 (7.1)	0 (0.0)	0 (0.0)	5 (2.1)	
Smoking	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.27
Yes	7 (16.7)	9 (9.8)	13 (11.9)	29 (11.9)	
No	19 (45.2)	46 (50)	82 (75.2)	147 (60.5)	
Not informed	16 (38)	37 (40.2)	14 (12.8)	67 (27.6)	
Diabetes mellitus	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.04
Yes	11 (26.2)	40 (43.5)	55 (50.4)	106 (43.6)	
No	29 (69)	47 (51.1)	54 (49.5)	130 (53.5)	
Not informed	2 (4.7)	5 (5.4)	0 (0.0)	7 (2.9)	
Respiratory diseases	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.87
Yes	8 (19)	14 (15.2)	16 (14.7)	38 (15.6)	
No	32 (76.2)	68 (73.9)	82 (75.2)	182 (74.9)	
Not informed	2 (4.8)	10 (10.9)	11 (10.1)	23 (9.5)	
Cardiovascular diseases	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.30
Yes	25 (59.5)	63 (68.5)	79 (72.5)	167 (68.7)	
No	15 (35.7)	24 (26.1)	26 (23.8)	65 (26.7)	
Not informed	2 (4.8)	5 (5.4)	4 (3.7)	11 (4.5)	

Table 4. *Cont.*

Variables	Normal Body Weight	Overweight	Obesity	Total	*p*
What pre-existing cardiovascular diseases?	*n* (%)	*n* (%)	*n* (%)	*n* (%)	<0.0001
Hypertension	18 (72.0)	32 (34.4)	68 (89.5)	118 (59.9)	
Hypertension + heart failure	5 (20.0)	50 (53.7)	9 (7.9)	64 (32.5)	
Other heart diseases	2 (8.0)	11 (11.8)	2 (2.6)	15 (7.6)	
Other chronic comorbidities	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.02
Yes	15 (36.6)	29 (31.5)	53 (50.0)	97 (40.6)	
No	25 (60.9)	58 (63.1)	49 (46.2)	132 (55.2)	
Not informed	1 (2.4)	5 (5.4)	4 (3.8)	10 (4.2)	
What other pre-existing chronic comorbidities?	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.56
Chronic dialysis kidney disease	8 (53.3)	13 (44.8)	25 (47.2)	46 (47.4)	
Neoplasms	5 (33.3)	9 (31)	11 (20.7)	25 (25.7)	
Others (depression, anxiety)	2 (13.3)	7 (21.2)	17 (32.1)	26 (26.8)	

Results are expressed as the median and interquartile (IQ) or as the number of individuals and the percentage (*n* (%)). Statistical analysis: & *Kruskal–Wallis* test with Dunn's post-test for quantitative variables and chi-square test (χ^2) for categorical variables. The variables for which there was no information in the medical record were not included in the statistical tests; they are represented as not informed. * $p < 0.05$ vs. normal body weight group.

Although a significant portion of patients in this study were categorized as non-smokers (n = 147, 60.5%), it is important to note that many medical records, n = 67 (27.6%), lacked information related to smoking habits.

It was observed that the presence of diabetes mellitus was significantly higher in the overweight and obesity groups when compared to the normal body weight group, p = 0.04 (Table 4).

Among patients with pre-existing respiratory diseases, COPD was the most prevalent condition (n = 26, 68.4%), affecting most patients in all groups, and no significant difference was observed between them. On the other hand, regarding pre-existing cardiovascular diseases, it was observed that 68.7% of patients presented some cardiovascular comorbidity, with hypertension the most common CVD, affecting 59.9% of patients (<0.0001), and it was higher in the obesity group.

For other prevalent chronic conditions, the obesity group was again the most affected (50%; p = 0.02), and kidney disease was the most frequently diagnosed, affecting 47.4% of all patients. It is noteworthy that most of these comorbidities were present in the overweight and obesity groups, as presented in Table 4.

In relation to other incident diseases, the ICU patients presented dengue fever (n = 11), history of previous surgery (n = 15), urinary infection (n = 9), pneumonia (n = 9), anemia (n = 9), leprosy (n = 1), and women in postpartum (n = 3).

3.4. Clinical Profile of Patients with COVID-19 Admitted to the ICU

In Table 5, it is observed that the total days of hospitalization were lower in the obesity group when compared with the normal body weight group, p = 0.02. This can be associated with the high rate of death, especially in the obesity group, which suggests that the obesity group has a worse clinical outcome. In addition, in Table 5, it is evident that most patients admitted to the ICU presented 1 to 7 days of symptoms (n = 116, 47.8%; p = 0.0003); however, the percentage of patients that presented 8–14 days of symptoms was higher in the obesity group when compared to the other groups. The predominant symptoms observed in these patients were dyspnea (30.4%), followed by cough (23.7%) and fever (18.7%). The statistical analysis revealed significant differences among the groups (p = 0.0003).

Table 5. Distribution and analysis of clinical profile of COVID-19 hospitalized patients in the intensive care unit at the Hospital Regional Jorge de Abreu in Sinop, MT and in accordance with BMI from March 2020 to March 2021.

Variables	Normal Body Weight	Overweight	Obesity	Total	*p*
n (%)	42 (17.3)	92 (37.9)	109 (44.9)	243 (100)	
Total hospitalization days [&]	17 (8–26)	14 (10–22)	11 (7–17)	13 (8–22)	0.02
Days of symptoms	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.0003
1 to 7	21 (50.0)	43 (46.7)	52 (47.7)	116 (47.8)	
8 to 14	11 (26.2)	19 (20.6)	43 (39.4)	73 (30.0)	
>14	5 (11.9)	18 (19.5)	3 (2.7)	26 (10.8)	
Without symptoms	4 (9.5)	1 (1.1)	5 (4.5)	10 (4.1)	
Not informed	1 (2.3)	11 (11.9)	6 (5.5)	18 (7.5)	
Main symptoms	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.0003
Dyspnea	35 (33.3)	79 (34)	99 (27.3)	213 (30.4)	
Cough	25 (23.8)	53 (22.8)	88 (24.3)	166 (23.7)	
Fever	17 (16.2)	47 (20.2)	67 (18.5)	131 (18.7)	
Myalgia	7 (6.6)	8 (3.4)	56 (15.5)	71 (10.1)	
Anosmia/hypogeusia	3 (2.8)	6 (2.5)	15 (4.1)	24 (3.4)	
Headache	10 (9.5)	24 (10.3)	14 (3.8)	48 (6.8)	
Others	8 (7.6)	15 (6.5)	23 (6.3)	46 (6.6)	
Chest CT scan	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.09
Yes	30 (71.4)	73 (79.3)	86 (78.9)	189 (78)	
No	11 (26.2)	11 (11.9)	20 (18.3)	42 (17.5)	
Not informed	1 (2.4)	8 (8.7)	3 (2.7)	12 (5)	
Image pattern found	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.02
Mild impairment (<25%)	11 (36.7)	14 (19.2)	15 (17.4)	40 (21.2)	
Moderate commitment (25–50%)	9 (30)	28 (38.3)	20 (23.2)	57 (30.1)	
Marked or severe (>50%)	8 (26.7)	28 (38.3)	49 (56.9)	85 (44.9)	
Other reports	2 (6.7)	3 (4.1)	2 (2.3)	7 (3.7)	
Mechanical ventilation	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.02
Yes	33 (78.5)	81 (88)	103 (94.5)	217 (89.3)	
No	8 (19)	11 (12)	6 (5.5)	25 (10.3)	
Not informed	1 (2.4)	0 (0.0)	0 (0.0)	1 (0.4)	
Tracheostomy	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.07
Yes	2 (4.9)	17 (21)	21 (18.6)	40 (16.5)	
No	39 (95.1)	64 (79)	92 (81.4)	195 (80.4)	
Other complications	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.03
Yes	23 (54.8)	62 (67.4)	78 (71.6)	163 (67)	
No	18 (42.8)	19 (20.6)	29 (26.6)	66 (27.2)	
Not informed	1 (2.3)	11 (12)	2 (1.8)	14 (5.8)	
Death	*n* (%)	*n* (%)	*n* (%)	*n* (%)	0.03
Yes	28 (66.7)	64 (69.5)	88 (80.7)	180 (74)	
No	13 (31)	26 (28.3)	17 (15.6)	56 (23)	
Not informed	1 (2.4)	2 (2.2)	4 (3.6)	7 (2.9)	

Results are expressed as the median and the interquartile (IQ) or as the number of individuals and the percentage (*n* (%)). Statistical analysis: [&] *Kruskal–Wallis* test with Dunn's post-test for quantitative variables and chi-square test (χ^2) for categorical variables. The variables for which there was no information in the medical record were not included in the statistical tests; they are represented as not informed.

Regarding chest CT scans, most patients in all groups underwent this examination, with no statistically significant differences between the groups ($p = 0.09$). Additionally, the prevalence of imaging patterns indicative of moderate (25 to 50%) or severe (>50%) pulmonary involvement was higher in the overweight and obesity groups, with a significant difference observed between the groups ($p = 0.02$) (Table 5).

Upon assessing the necessity for mechanical ventilation, a statistically significant difference between the groups was observed, with a significantly higher percentage of overweight (88.0%) and obese (94.5%) patients requiring mechanical ventilation compared to normal body weight individuals (78.5%), $p = 0.02$.

No statistically significant difference was observed between the groups regarding the need for tracheostomy, with 16.5% of patients requiring this intervention ($p = 0.07$); however, it is important to mention that 21% of overweight patients and 18.6% of patients with obesity required tracheostomy and only 4.9% of normal body weight patients needed this intervention, with the percentage higher in patients with BMI ≥ 25 kg/m^2 (Table 5). Furthermore, there was a statistical difference between the groups concerning the variable "other complications," with a higher percentage of individuals in the overweight and obesity groups experiencing several complications during the period of hospitalization ($p = 0.03$).

When evaluating the percentage of patients diagnosed with COVID-19 and admitted to the ICU who subsequently died, a statistically significant difference was noted between the groups, with a significantly higher percentage in the overweight (69.5%) and obesity (80.7%) groups compared to the normal body weight group (66.7%), $p = 0.03$ (Table 5). Furthermore, it is important to note the high percentage of mortality rate in patients hospitalized in the ICU before the period of vaccination.

Finally, in Table 6, the values of the odds ratios for obesity vs. normal body weight groups and the incidence of complications or a worse prognosis can be observed. It was demonstrated that obesity is, in fact, a risk factor for the necessity of mechanical ventilation, the necessity of tracheostomy, the incidence of complications, and deaths, as the presence of obesity significantly increases the chance of a hospitalized COVID-19 patient presenting a worse clinical evolution. In addition, in accordance with the multivariate regression analysis (R2 = 0.07124/$p = 0.0003$) described in Table 6, it can be observed that obesity = 0.01647 (95% CI 0.007759 to 0.02517; $p = 0.0002$) and age in years = 0.006298 (95% CI = 0.002527–0.01007; $p = 0.0011$) significantly increased the risk of death in ICU-hospitalized COVID-19 patients.

Table 6. Analysis of clinical profile, odds ratio (OR), and multiple linear regression analysis of COVID-19 hospitalized patients in the ward and the intensive care unit at the Hospital Regional Jorge de Abreu in Sinop, MT and in accordance with BMI from March 2020 to March 2021.

ICU	Normal Body Weight	Obesity	Total	OR	*p*
Mechanical ventilation	*n* (%)	*n* (%)	*n* (%)		
Yes	33 (80.5)	103 (94.5)	136 (90.7)	4.12	0.009
No	8 (19.5)	6 (5.5)	14 (9.3)	(1.26–13.28)	
Tracheostomy	*n* (%)	*n* (%)	*n* (%)		
Yes	2 (4.9)	21 (18.6)	23 (14.9)	4.45	0.03
No	39 (95.1)	92 (81.4)	131 (85.1)	(1.05–19.86)	
Other complications	*n* (%)	*n* (%)	*n* (%)		
Yes	23 (56.1)	78 (72.9)	101 (68.2)	2.11	0.04
No	18 (43.9)	29 (27.1)	47 (31.8)	(1.00–4.38)	

Table 6. *Cont.*

ICU	Normal Body Weight	Obesity	Total	OR	*p*
Death	*n* (%)	*n* (%)	*n* (%)		
Yes	28 (68.3)	88 (83.8)	116 (79.5)	2.40	0.04
No	13 (31.7)	17 (16.2)	30 (20.5)	(1.01–5.45)	
Multiple linear regression analysis of incidence of deaths in patients in the ICU (R squared = 0.07)					
Sig. diff. than zero?	Variable	|t|	95% Confidence Interval		*p* value
β1	Age in years	3.288	0.002527 to 0.01007		0.0011
β2	BMI	3.723	0.007759 to 0.02517		0.0002
β3	Diabetes?	0.7968	−0.06474 to 0.1528		0.4263
β4	CVD?	1.889	−0.2334 to 0.004812		0.0599

Results are expressed as the number of individuals and the percentage (*n* (%)). Statistical analysis: chi-square test (χ^2) for categorical variables; OR—odds ratio with 95% confidence interval and multiple linear regression analysis. ICU = intensive care unit; BMI = body mass index; CVD = cardiovascular disease.

4. Discussion

Among the patients admitted to the ward and to the ICU who presented BMI data in their medical records, the majority of them had a BMI of more than 25, being overweight or obese. In all groups, most patients were male, over 50 years old, married, non-smokers, and white. Although all ages are vulnerable, ages above 40 years old stand out, with the most diagnosed cases in the age group between 40 and 56 years and a higher incidence of the disease in male patients [1].

In our study, no statistical differences between groups were observed regarding marital status and ethnicity, the majority being married and white. According to McIntosh [17], black, Hispanic, and South Asian individuals account for a disproportionately high number of infections and deaths from COVID-19 in the United States and the United Kingdom, probably based on social determinants of health. However, some analyses that have controlled for comorbidities and socioeconomic profile have not found an association between African American or Hispanic ethnicity and worse COVID-19 outcomes in hospitalized patients.

Regarding the relationship between smoking and the pathophysiology of COVID-19, it is known that an inflammatory process is commonly found in chronic smokers, with immunological changes caused by cigarette smoke being verified, including an increase in inflammatory cells, mainly monocytes and macrophages, in addition to pro-inflammatory cytokines, such as interleukin β (IL-β), tumor necrosis factor alpha (TNF-α), and interleukin 6 (IL-6) [18]. However, in our study, no statistical difference was observed concerning smoking between groups.

Several studies demonstrate that overweight and obesity increase the development of other diseases, such as diabetes and cancer [9]. In the present study, it was observed that the prevalence of diabetes was higher in patients with overweight and especially obesity (Tables 1 and 4), which could contribute to the worse clinical profile of patients, as in a diabetic condition associated with obesity more metabolic alterations could be present, such as hyperglycemia and glucotoxicity, leading to oxidative stress and vascular alterations, thus contributing to increasing the risk hospital complications, the necessity of mechanical ventilation, and deaths. Furthermore, in accordance with the multiple linear regression analysis presented in Table 3, it can be observed that only in patients hospitalized in the ward did diabetes contribute as a risk factor for deaths.

Studies suggest that patients with diabetes mellitus have an increased risk of adverse cardiovascular outcomes when infected with SARS-CoV-2, including a higher likelihood of requiring intensive care and developing acute cardiovascular events during hospitalization [19].

The study by Al-Sabah et al. [20] found that patients with diabetes mellitus, a chronic metabolic pathology characterized by high blood glucose levels as a result of insulin resistance or insufficient insulin production, are more likely to suffer serious illnesses and complications from COVID-19, increasing the likelihood of these patients having to be transferred to ICU care.

Hospitalized patients diagnosed with COVID-19, especially those with comorbidities, such as diabetes, have an increased risk of cardiovascular complications, such as myocardial infarction, arrhythmias, and deep vein thrombosis. Systemic inflammation and endothelial dysfunction are some of the mechanisms that may contribute to these cardiovascular complications, as well as severe respiratory disease [21].

Our data showed that patients who were overweight and obese had worse clinical evolution, with more complications and deaths. This corroborates with the current literature, showing that the severity of the COVID-19 disease is directly associated with an increase in BMI. Obesity is an independent risk factor for morbidity and mortality from SARS-CoV-2 infection [22].

Nascimento et al. [23] investigated the demographic and clinical profiles of hospitalized patients in Brazil with COVID-19 and Crohn's disease (CD) over a two-year period. The most prevalent comorbidities were heart disease (30.2%), diabetes mellitus (15.1%), immunosuppressive disease (13.7%), obesity (5.9%), and pulmonary disease (5.1%). Heart disease, diabetes mellitus, and obesity were associated with a higher likelihood of SARS-CoV-2 infection. The multivariable analysis identified that obesity (OR = 6.922; 95% CI = 1.605–29.849), cough, fatigue, ageusia, headache, need for ventilatory support, and death due to SARI were predictors of infection. On the other hand, race and death unrelated to SARI were protective factors against a COVID-19 diagnosis.

Our study shows that most patients admitted to the ward and the ICU had a BMI $\geq$ 25 kg/m^2 (overweight/obesity), as shown in Tables 1 and 3, respectively, highlighting how the presence of overweight is a significant risk factor for the hospitalization of the patient and a worse prognosis, in line with several studies that have evaluated this relationship. Similar results were observed in our previous study comparing patients hospitalized in the ward and in the ICU, demonstrating that the majority of patients presented a BMI $\geq$ 25 kg/m^2 [24]. In patients with COVID-19, according to the distribution of excess adipose tissue, degree, and duration, obesity may be responsible for causing or exacerbating a variety of comorbidities, including type 2 diabetes mellitus, hypertension, dyslipidemia, cardiovascular disease, and kidney disease [25]. Chronic inflammation attributed to adipose tissue may be an inducer of the occurrence of the cytokine storm that may be linked to a variety of complications of COVID-19 [26]. A variety of comorbidities and underlying conditions have been associated with severe illness (i.e., increased time of hospitalization, ICU admission, intubation, mechanical ventilation, and death) [17].

As mentioned in the introduction section, the virus uses ACE2 as a receptor. It mainly infects ciliary bronchial epithelial cells and type II pneumocytes, which explains why symptoms in the respiratory system are common [27]. The main transmission routes are inhalation of respiratory droplets from infected people or previously contaminated surfaces, direct contact with mucous membranes, and inhalation of suspended particles [28]. In our study, there was no difference between groups regarding the signs and symptoms presented in all groups on the ward, but they were different between groups of ICU patients.

No statistically significant difference was observed between the days of symptoms presented by patients in the normal body weight, overweight, and obesity groups, p = 0.83 (in the ward); however, in the ICU, an expressive percentage of patients in the obesity group stayed in the hospital for 8 to 14 days (39.4%), and 22.2% of patients with a BMI $\geq$ 25 kg/m^2 presented more than 14 days of symptoms compared to 11.9% of patients with normal body weight. The main symptoms reported were dyspnea, cough, and fever. Our data on the main symptoms are consistent with the study by Asselah [27], in which the symptoms most reported by patients were fever, dry cough, fatigue, and dyspnea.

Computed tomography (CT) was widely used as a complementary exam for diagnosis and clinical evaluation during the COVID-19 pandemic in this field of research. CT assists in assessing typical characteristics of the lung parenchyma and small airways, providing an accurate assessment of the pattern, distribution, and evaluation of the potential for reversibility of lung disease, in addition to correlating them with lung function tests. Ground-glass opacification refers to focal or diffuse veil-like opacification of the lung that does not impede visualization of vascular structures or other anatomical details and does not produce air bronchograms, indicating parenchymal abnormalities. The initial exudative form of SARS-CoV-2 pneumonia is expressed by multifocal, large, rounded, and subpleural ground-glass opacities [29].

Regarding the image pattern found, the group of obese patients in our study had a higher incidence of the pattern of marked or severe ground-glass impairment (>50% of the lung parenchyma).

Regarding hospital complications, such as the need for mechanical ventilation and the incidence of other complications, it can be observed that the incidence of these harmful outcomes was significantly higher in the obesity group when compared to the overweight and normal body weight groups, demonstrating that obese patients have a more severe clinical condition and a higher risk of death.

Chronic inflammation of adipose tissue appears as a triggering factor, as the marked release of inflammatory cytokines predicts the worsening of severe respiratory disease [30]. These data align with the study by Chiumello et al. [31], which demonstrates that patients who required mechanical ventilation for ARDS mostly had a BMI ≥ 25 kg/m^2. Thus, it is acceptable to predict that the accumulation of adipose tissue as a pathophysiological mechanism is an essential parameter for the prognosis of patients with COVID-19.

Our data corroborates other studies in which the increased need for mechanical ventilation proved to be proportionally true to the degree of obesity; that is, the individual with obesity has a greater chance of a worse prognosis than a patient with normal body weight [26,30,31].

In the context of other complications caused by the disease COVID-19, obesity is related to complications mainly harming the respiratory system. The most cited are ARDS and pneumonia, which have lung lesions, low saturation, and the need for mechanical ventilation when aggravated [30–33].

In Brazil, obesity is the main comorbidity associated with deaths in people under 60 years. In addition, the risk of complications and death from COVID-19 is up to four times greater in these patients with a high BMI [22,34]. This data are also similar to ours (Tables 2 and 5).

Although a significant portion of patients in this study were categorized as non-smokers, it is important to note that many medical records lacked information related to smoking habits. As observed in the study by Nascimento et al. [35], smoking emerged as one of the most common risk factors for hospitalization in general. This finding is supported by the descriptive analysis conducted by Paiva et al. [36] in the state of *Paraná*, Brazil. It is worth emphasizing that patients with a history of smoking had a significantly higher likelihood of requiring mechanical ventilation, thereby increasing the risk of developing other respiratory conditions and acute respiratory distress syndrome, one of the leading causes of mortality [37].

As previously mentioned, specific individuals have a higher propensity to progress to severe forms of COVID-19, such as the elderly, obese individuals, and those with non-communicable chronic diseases, primarily cardiovascular diseases, such as hypertension and diabetes mellitus. These individuals often require more intensive care and respiratory support, rendering them more susceptible to mortality [38], as observed in the present study.

An analysis of severe outcomes in a study examining health records of 6,910,685 individuals who contracted COVID-19 in England based on data retrieved from the national QResearch database for patients aged 20 and older during the period from January to April 2020 revealed that as the BMI exceeded 23 kg/m^2, there was a more frequent progression of COVID-19, with a "significantly increased risk for each unit increase in BMI." The study concluded that each unit increase in the BMI indicator raised the risk of hospitalization by 5% and the likelihood of ICU admission by 10% independent of pre-existing health conditions, including type 2 diabetes mellitus [39].

It is well-established that individuals with excess weight often exhibit a state of chronic low-grade inflammation, insulin resistance, compensatory hyperinsulinemia, hyperglycemia, and oxidative stress, among other metabolic alterations, which can increase the risk of developing various diseases and clinical complications, thereby increasing morbidity and mortality in patients [11,40]. In fact, in this study, we observed more complications and a worse clinical prognosis in patients with a BMI ≥ 25 kg/m^2.

Some limitations of this study were the fact that many medical records did not contain weight and/or height data, which made it impossible to calculate the BMI, and the fact that some variables presented incomplete data. This resulted in a reduction in the number of patient samples, mainly in the ward.

5. Conclusions

In conclusion, this study demonstrates that the clinical picture of patients with COVID-19 admitted to the ward and the ICU was more severe in patients with obesity when compared to overweight and normal body weight patients. Furthermore, the need for mechanical ventilation, the incidence of complications, and the death rate was also higher in these patients, presenting a worse prognosis.

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Informed Consent Statement: Patient consent was waived as the study involved only the analysis of the medical records, and it was dispensed by the Ethics Committee.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

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